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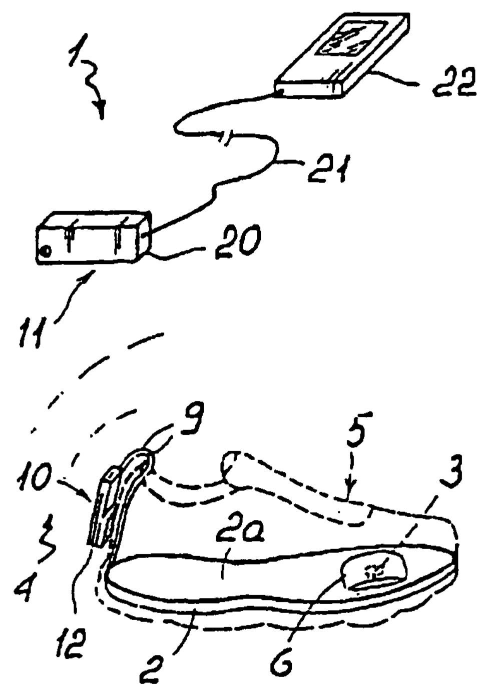
(54) Title: DETECTING DEVICE FOR THE FORCES DEVELOPING UNDER THE FOOT



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(57) Abstract: A device (1) is provided comprising a base unit (2) defined by an insole having a rest surface (2a) substantially in contact with at least one portion of the foot plantar surface, at least one sensor (3) supported by the base unit (2) adjacent to the rest surface (2a) and apt to detect the force exerted thereon by the plantar surface, and means (4) apt to transmit, process and visualize the detections of sensor (3) connected to the latter and at least partially

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external to the base unit (2), device (1) furthermore comprising at least one force-distributing member (6) supported by the base unit (2) and active on the sensor (3), the force-distributing member (6) being apt to transform localized forces active thereon into uniformely distributed specific pressure.

DETECTING DEVICE FOR THE FORCES DEVELOPING UNDER THE FOOT

DESCRIPTION

An object of the invention is a device apt to detect forces developing under the foot, for example apt to show the pushing, pulling or resting forces exerted by the foot during a sporting activity.

As it is known, detecting the forces exerted at the foot is important in various human activities and particularly in the field of sports such as high jump, long jump, cycling, boat racing, all race types, kicking, while playing soccer etc.

In fact, the exact reading of the force developing under the foot gives the athlete the possibility of changing his/her behaviour so as to optimize physical performance, apart from measuring his/her own power and energy.

The optimization of physical performance may be obtained, for example, by visualizing the pattern of the force exerted by the foot during excercises, or by calculating the overall energy consumed during exercises, by the power expressed as a function of behaviour or posture, or even by programming the applied forces and the energetic consumption vs. time.

The reading of the force exerted by the foot has been up to now measured in two different ways: by utilizing scales or footplates or devices implementing substantially outer supports for the foot, or by means of special resting plates substantially plane and which plates can also be insertable into footwear, which are equipped with several sensors detecting the relative variation of local stresses.

Both said technical solutions have various and important inconveniences.

The scales have the inconvenience of providing an overall or averaged and not localized reading of the foot stresses and therefore of providing in several cases not sufficiently significant data.

Furthermore, they have the inconvenience that they can be used in sporting activities only in a limited number of cases.

Moreover, they are expensive and require specific rooms and equipment.

The rest plates which are insertable into footwear, in turn, have the inconvenience of having to be pre-arranged in great number or varieties to fit various foot sizes and, above all, provide too localized and changing values of stresses, contrary to scales.

In fact, not only the points of maximum foot stress vary according to situations and posture, but also the foot position in the footwear varies within certain limits, thus modifying the data detected by sensors.

Furthermore, also the foot contact area on the insole varies according to position and stress entity: the higher the stresses, the greater the areas engaged, with consequent unload of forces out of the initially engaged sensors.

Practically, the great and unforeseeable variety of localized stresses, even in this case, forces to consider especially averaged and overall values.

In fact, it is substantially useless to consider, for example, the exact stresses detected by sensors placed inside a footwear, when it is known that, under maximum engagement conditions, foot and footwear get deformed so as to distribute the stresses over a quite various surface.

Therefore, the technical problem of how exactly measuring temporary and local foot stresses, in particular during sporting activities, is still an unsolved problem.

In this situation, the technical task the present invention is based upon is to devise a device able to substantially obviate the mentioned inconveniences and to resolve the above said technical problem.

Within the scope of said technical purpose, it is an important object of the invention to devise a device which, although allowing the measuring of localized stresses so as to allow even point by point checking of the foot stresses, results reliable even when foot displacements or deformations or changes of the rest area of the same occur.

Another important object of the invention is to devise a device which, although allowing the measuring of the localized stresses, is suitable for various shapes and sizes of foot and shoe.

Still another object of the invention is to implement a device suitable for substantially all sporting activities and for all cases wherein measuring the foot local stresses is required.

A further object is to devise a substantially cheap device, with small overall dimensions.

The technical task and the specified objects are substantially obtained by a device apt to detect the forces developing under the foot, characterized in that it comprises any of the new technical solutions hereinafter described and claimed, or any combination of the same.

By way of example and not for limitative purposes, the description of a preferred embodiment of a device according to the invention is now shown, illustrated in the enclosed drawings, wherein:

Fig. 1 shows in a schematic and perspective way the device, as a whole, in a particular application thereof;

Fig. 2 illustrates with a plan view a sensor utilized in the device of Fig. 1;

Fig. 3a highlights a cross-sectional portion of the device including the sensor of Fig. 2, in a stand-by position;

Figs. 3b, 3c are similar to Fig. 3a, but in operating positions;

Figs. 4 and 5 show a plan and cross-sectional view of an insole incorporating the members of Fig. 3a;

Fig. 6 is similar to Fig. 4 and shows a plan view of an insole equipped with a plurality of sensors;

Fig. 7 shows a functional scheme of a receiver group of the device; and

Fig. 8 shows a functional scheme of a transmitter group of the device, functionally connected to the receiving group of Fig. 7.

By referring to the above mentioned Figures, the device according to the invention is designated as a whole with numeral 1.

It summarily comprises a base unit 2 having a rest surface 2a substantially in contact with at least one portion of the foot plantar surface, and at least one sensor 3 supported by the base unit 2 adjacent to the rest surface 2a and apt to detect the force exerted thereon by the foot plantar surface.

Means 4 is then provided, apt to transmit, process and visualize the detections of the sensor 3, connected thereto and at least partially external to the base unit 2.

Inventively, the base unit 2 is an insole of a footwear 5, as shown in the Figures. The insole 2 is provided very flexible and therefore advantageously suitable for variously-shaped footwear 5.

The insole 2 may incorporate one or more sensors 3. For example, in the Figures 1 to 5 insoles 2 with only one sensor 3 at the forefoot are shown, whereas in Fig. 6 an insole 2 equipped with nine sensors 3 is shown.

The sensor 3 may be of various types and in the Figures a flat sensor, called "Force Sensing Resistor", commonly available on sale, is shown by way of example.

This sensor 3 has two separate comb-like electric conductors 3a both rested on a conductive base 3b. Upon variation of the pressure on the sensor 3, the resting and contact area between each comb-like electric conductor 3a and the conductive base 3b varies and therefore the resistance and current flow vary too.

The sensor 3 of said type is implemented as a reed of various sizes, so as to engage areas of different sizes. Nevertheless, inventively, in the device according to the invention, sensors 3 always equal and of small sizes are usable, even to control wide areas, or sensors with various sizes, as will be described later.

A characterizing aspect of the present invention lies in the fact that at each sensor 3 at least one distributing forces member 6 is provided, apt to transform also

the localized forces into uniformly distributed specific pressure, detectable by a sensor 3.

This force-distributing member is made of a flexible closed case 7 and of a fluid 8 filling the case 7.

Advantageously, the case 7 is a bag or the like and it is shaped as a cushion, prevalently flattened.

The bag-or-cushion-like case 7 may be substantially defined by two sheets overlapped and thermowelded between themselves at edges 7a.

The cases 7 are firmly applicable to the insole 2 for example by simple glue 7a on the rest surface 2a, as shown in Figs. 3a, 3b, 3c, or by drowning inside the insole 2, as shown in Fig. 5.

In the first case, any insole 2 on sale may be utilized, whereas in the second case the insole 2 has to be manufactured on purpose, for example by forming it with two overlapped layers, between which the force distributing members 6 and the sensors 3 are inserted.

The electric wires 9 originating at the sensors 3 must have anyway terminations outer the insole 2.

The fluid 8 filling the case 7 is preferably simple air, but it may be another gaseous or liquid fluid.

Examples of usable liquids are water or oil.

Air has the advantage of being highly compressible and therefore of making the cases 7 little invasive, so as not to disturb the foot, even when the cases 7 are placed over the rest surface 2a.

Liquids, instead, have the advantage of immediately transmitting the stresses applied thereon and are more suitable for cases 7 drown in the insole 2.

Advantageously, as it is evident from Fig. 6, showing nine sensors 3 and nine forces distributing members 6, sensors 3 have constant and minimum sizes, whereas the force-distributing members are dimensioned according to the extension of the region to be controlled and therefore have a plan development much wider than that of the sensors 3.

Sensors 3 may have any position with respect to the relative force-distributing members 6, provided that they are in physical contact with the latter.

For example, they could be inside the members 6, that is inside the cases 7 when these are filled with an insulating fluid 8, such as air, and therefore they could form with said members a compact and complete unit, immediately applicable, in any position, to the insole 2, for example by simply gluing.

Anyway, in the cases illustrated in the Figures, sensors 3 are external to the cases 7.

In Figs. 3a, 3b, 3c, the sensors are interplaced between the rest surface 2a and the cases 7 and may be glued to the surface 2a or to the cases 7, in this last case still forming a compact unit.

The means 4 apt to transmit, process and visualize the detections of each sensor 3 is connected to electric wires 9 and may be of various type, depending from the particular control requirements.

Preferably, as Fig.1 highlights, they are divided into a transmitter group 10 and a receiver group 11.

The main members forming the transmitter group 10 are schematized in Fig. 8, whereas the main members of the receiver group 11 are schematized in Fig. 7, by way of example.

It is noticed that the transmitter group 10 comprises a box-shaped member 12 of small size arranged in a fixed position with respect to the insole 2, for example on the external part of the heel of the shoe 5 wherein the insole 2 is arranged.

The electric wires 9 are made to pass under or at the edges of the insole 2 until reaching the heel of the shoe 5. Here, they may pass through the shoe or simply pass above the heel and being connected to the box-shaped member 12.

The support of the box-shaped member on the shoe heel may be obtained simply by means of velcro. In this way, the shoe is not damaged and any footwear can receive the insole 2 and support the box-shaped member 12.

The box-shaped member 12 preferably contains, summarily, an electric power supply 13 and a microprocessor 14 whereto, according to usual electronic techniques for treating electric signals, amplifyers 15, an oscillator 16, a modulator 17 and a transmitter 18 are connected.

The latter may be of various types and, in the illustrated case, an infrared-ray transmitter 18 is preferred.

Nevertheless, the box-shaped member 12 can alternatively incorporate or support ultrasound or radio-wave or wire transmitters or other.

Furthermore, in Fig. 8 a switch 19 is highlighted, which interrupts all the electric power supply after a predetermined period of inoperativity.

The receiver group 11 is divided into a second box-shaped member 20 connected by a wire 21 to a visualizer 22, as highlighted in Fig. 1.

By way of example, the second box-shaped member 20 comprises, summarily, a second electric power supply 23 and a second microprocessor 25 whereto a receiver 25 able to perceive the signals emitted by the transmitter 18, a permanent memory 26

and members 27 apt to send the stored data to apparatuses processing the same are connected.

These members 27 can be variously chosen and can also consist in a simple interface for cable connection.

The second box-shaped member 20 and the visualizer 22 are always of small sizes and in particular the visualizer 22 can have the shape of a small portable viewer.

As a whole, the electronics is provided structural so as to "observe" and store all sensors 3 contemporarily, to give an idea about the pattern vs. time of forces, in the various development steps, for example, of a sporting gesture.

Furthermore, it is structured so as to process the observed forces in all the useful ways.

It is noticed that the electric power supplies 13 and 23 are obtainable with small electric batteries, for example tablet-like, or, at least for the first electric power supply 13, by piezoelectric quartzes apt to inventively provide the system power supply by transforming mechanical energy into electric energy.

It is clear, then, that the various electric and electronic members mentioned above may be variously distributed between the first box-shaped member 12, the second box-shaped member 20 and the visualizer 22, and also the wire connection 21 may be not necessary or replaced by another type of data transmission.

The functioning of the device, as above described in a mainly structural sense, is the following.

At an insole 2, which is then inserted into a footwear 5. one or more sensors 3, even all equal, are positioned. To these sensors 3 the force distributing members 6, of various sizes and proportioned to the single areas to be controlled, are applied. The practical functioning of members 6 with respect to sensors 3 is highlighted in Figs. 3a, 3b, 3c.

In Fig. 3a the member 6, which in the specific case is a small bag full of air and sealingly-closed, is free from stresses and no pressure is applied to the underneath sensor 3.

In Fig. 3b a uniform pressure is instead applied, on the member 6, which causes a more or less accentuated deflection of said member. The deflection transforms into a uniform inner pressure and therefore the pressure exerted on the sensor 3 depends not only on the stresses applied immediately above the same, but also on the stresses displaced in a lateral direction.

In other words, the sensor, even if of small size, detects the stresses applied to the whole upper area of the member 6.

Then, Fig. 3c highlights that the sensor 3 is able to detect, thanks to the presence of the member 6, also a deflection localized mainly in a position spaced with respect to the sensor 3 itself, but still within the area engaged by the member 6.

In fact, the localized deflection always transforms into pressure inside the member 6 and uniform in all points and therefore acting on the sensor 3 too.

As a whole, it turns out to be possible to detect the stresses in a certain region of the foot, or in more regions, independently from the footwear shape, from the foot shape and from the varying of the positions of foot in the footwear, since anyway the members 6 intercept these stresses and transmit them to sensors.

Moreover, the phenomenon upon which the reliability of detections changes as the stresses' entity varies, even independently from the above mentioned uncertainty elements is avoided.

In fact, by increasing the stresses, the area of the insole 2 which resists the stresses increases spontaneously, and therefore these unload more and more outside the area of the sensor 3.

The presence of the member 6 eliminates this situation since by increasing the stresses, there is no alternative to a greater deflection of the member 6.

The stresses could sensibly burden outside a member 6, in a determined region of the insole 2, only when the member would result wholly flattened, a practically not reachable situation.

The data detected by sensors 3 can be accurately characterized or calibrated so as the values of the applied stresses are exactly measured.

In fact, it is possible to characterize the insole 2 outside the footwear 5 during manufacturing: on the various members 6 known and gradually increasing pressures are applied and contemporarily the responses of the sensors 3 are detected.

The data transmitted by the sensors 3 are sent to the transmitter group 10, light and immediately adjacent to the heel of the footwear, for example. Then, they are transmitted to the receiver group 11, which for example is carried by an athlete's cloths, or it is supported by a bicycle, canoe, or others.

The data may be stored, visualized instant by instant, variously processed and also remotely transmitted for more complex processings and/or for comparison with other sporting gestures.

The invention achieves important advantages.

In fact, the inconveniences of the prior art are wholly overcome and a precise device has been made available, which is reliable in each situation, suitable for various uses, simple and light.

The invention is susceptible to several changes and variants, all within the scope of the inventive core.

All the details are replaceable by equivalent members and the materials, shapes and sizes could be any.

CLAIMS

1. A device apt to detect the forces developing under the foot, of the type comprising a base unit having a rest surface substantially in contact with at least one portion of the foot plantar surface, at least one sensor supported by said base unit adjacent to said rest surface and apt to detect the force exerted thereon by said plantar surface, and means apt to transmit, process and visualize detections of said at least one sensor, connected to the latter and at least partially external to said base unit,

characterized in that it comprises at least one force-distributing member supported by said base unit and active on said at least one sensor, said force-distributing member being apt to transform localized forces active thereon into uniformly distributed specific pressure.

2. The device according to claim 1, wherein said base unit is a footwear insole.

3. The device according to one or more of the preceding claims, claim 2 in particular, wherein said insole is flexible and suitable for variously shaped footwear.

4. The device according to one or more of the preceding claims, claim 1 in particular, wherein said at least one sensor is external to said at least one force-distributing member.

5. The device according to one or more of the preceding claims, claim 4 in particular, wherein said at least one sensor is placed above said rest surface and wherein said at least force-distributing member is interplaced between said sensor and said plantar surface.

6. The device according to one or more of the preceding claims, claim 1 in particular, wherein said at least one force-distributing member is sized according to the size of the region to be controlled and has a plan development wider than that of a respective sensor.

7. The device according to one or more of the preceding claims, claim 1 in particular, wherein said at least one force distributing member is a flexible case, sealingly-closed and filled with a fluid.

8. The device according to one or more of the preceding claims, claim 7 in particular, wherein said case is shaped as a substantially flattened cushion and wherein said fluid is air.

9. The device according to one or more of the preceding claims, claim 1 in particular, wherein said means apt to transmit, process and visualize the detections of said at least one sensor comprises a transmitter in a fixed position with respect to said base unit, a receiver spaced out from said transmitter, a visualizer connected to said receiver.

10. The device according to one or more of the preceding claims, claim 9 in particular, wherein said transmitter is of infrared-ray type.

11. The device according to one or more of the preceding claims, claim 1 in particular, wherein said means apt to transmit, process and visualize the detections of said at least one sensor comprises a memory to store the gathered data.

12. The device according to one or more of the preceding claims, claim 1 in particular, wherein said means apt to transmit, process and visualize the detections of said at least one sensor comprises members apt to send the gathered data to apparatus processing the same.

13. The device according to one or more of the preceding claims, claim 1 in particular, wherein said means apt to transmit, process and visualize the detections of said at least one sensor is associated with piezoelectric quartzes apt to provide the system power supply by transforming mechanical energy into electric energy.

14. A device apt to detect the forces developing under the foot, characterized in that it comprises any combination of the claimed technical solutions.

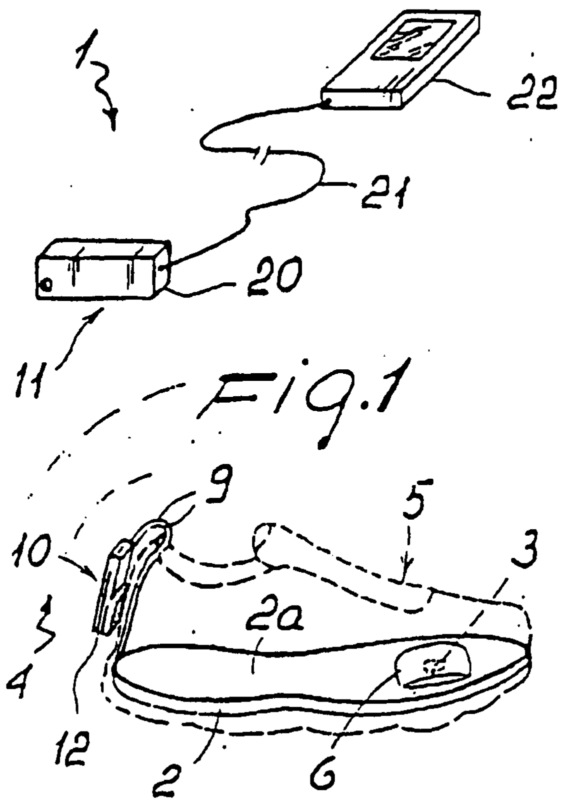
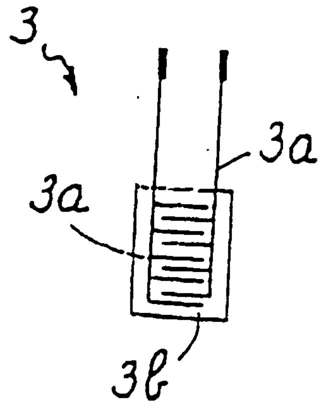


Fig.1

Fig.2



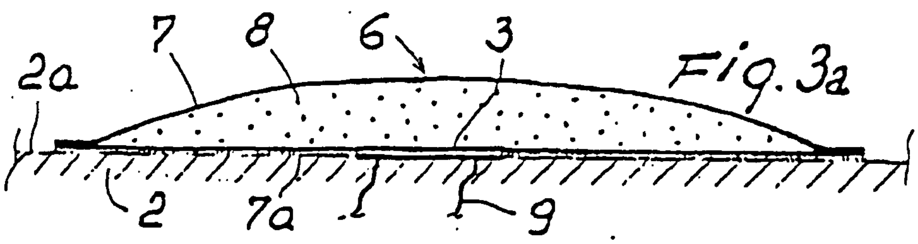


Fig.3a

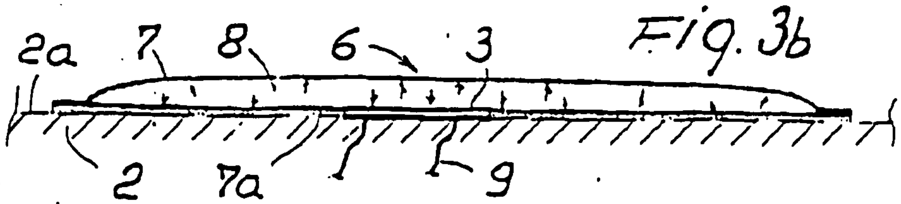


Fig.3b

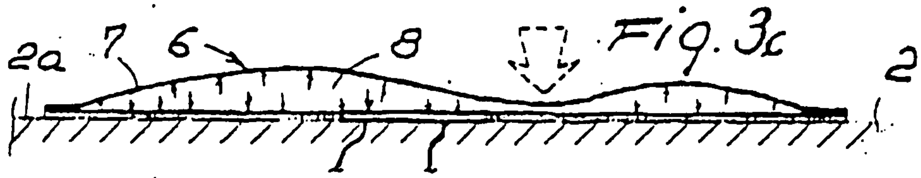


Fig.3c

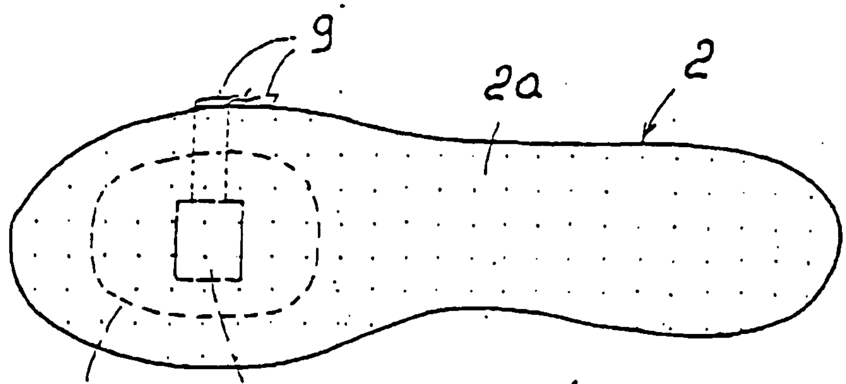


Fig. 4

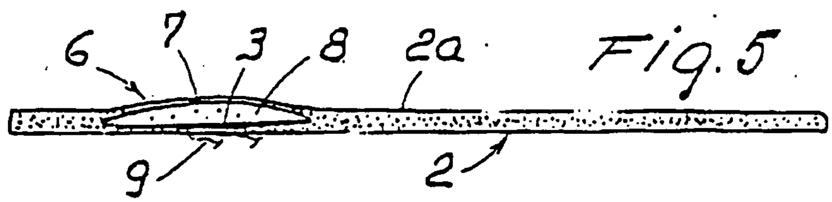


Fig. 5

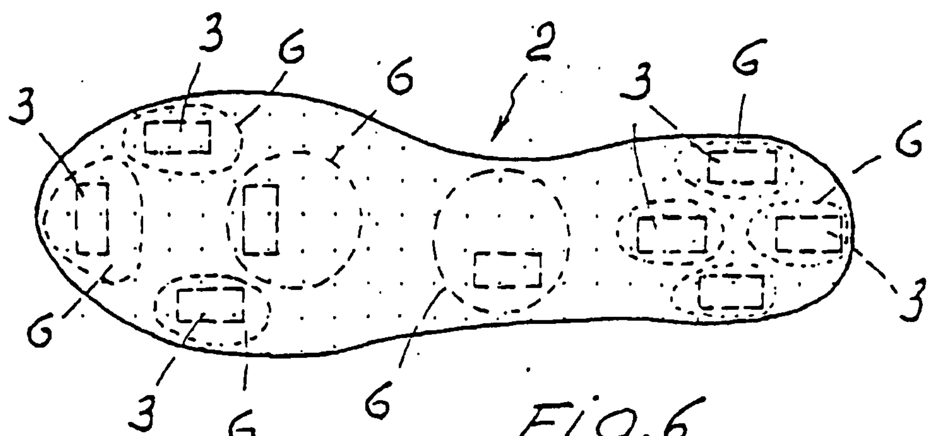


Fig. 6

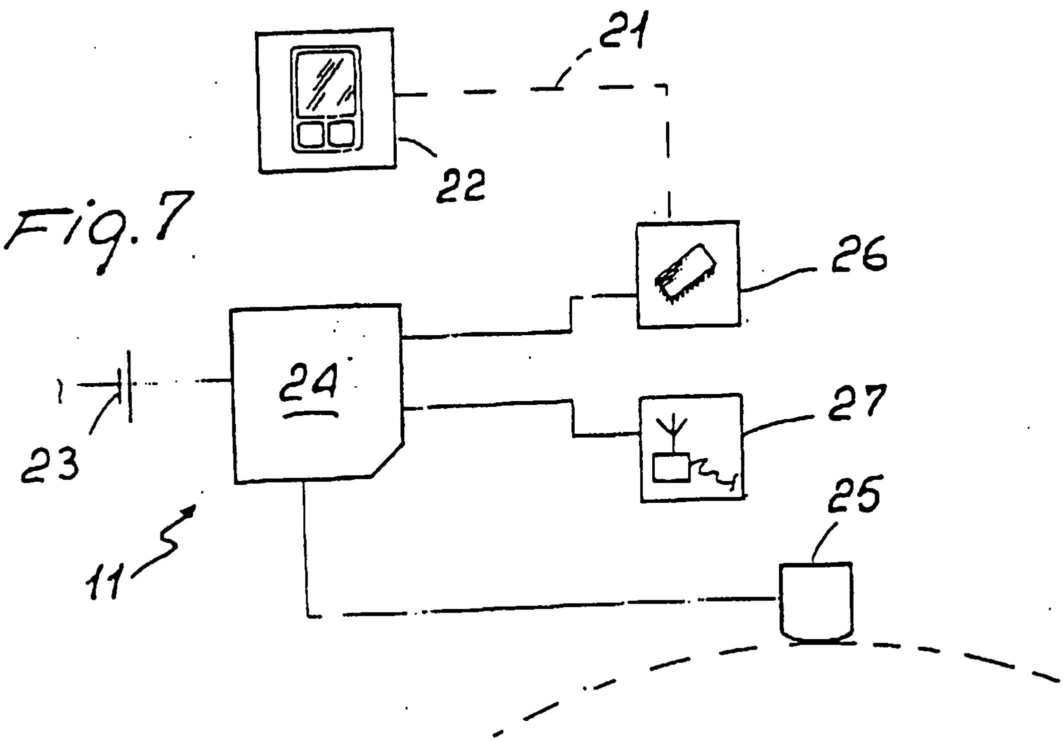


Fig.7

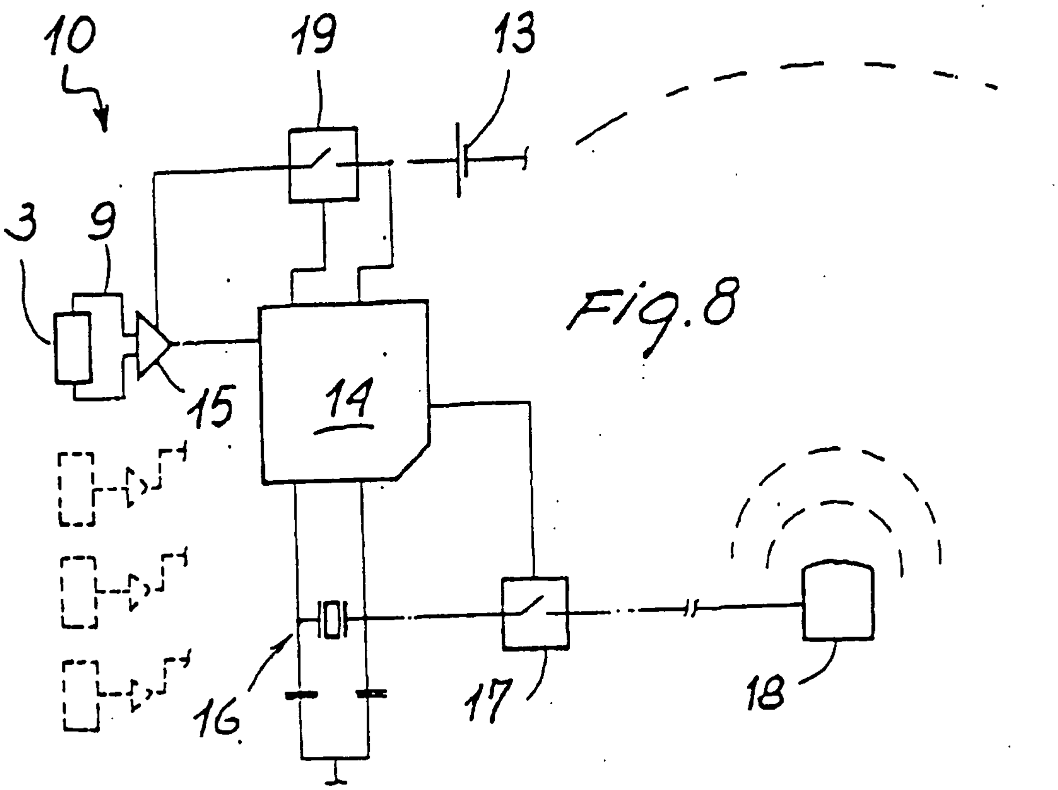


Fig.8